5 December 1967

Materiel Test Procedure 5-2-530
White Sands Missile Range

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

TRANSMITTER TESTS

1. OBJECTIVE

The objective of the procedures outlined in this MTP is to ascertain transmitter characteristics.

2. BACKGROUND

Transmitters are used to provide the radio frequency (RF) power required to radiate RF energy on a target (for target acquisition or target tracking purposes) and to provide guidance because of the accuracy and reliability required of transmitters, engineers and other personnel engaged in testing and evaluation of them have developed certain procedures for testing. The procedures are used to prove that the transmitter will meet the design requirements as well as the anticipated needs of the overall system it is to serve.

Tests for the different types of transmitters are essentially the same with somewhat different techniques used for specific tests. For instance, pulse characteristics are important in a pulse type transmitter, but are non-existent in a continuous wave (CW) transmitter. In addition, the procedures are applicable to transmitters used for telemetry, radar, "Identification Friend or Foe" (IFF) beacons, and communications systems. An engineering evaluation of a transmitter requires testing of the following transmitter characteristics:

a. Power output
b. Frequency
c. Pulse
d. Modulation

The transmitter must adhere to government and manufacturer's specifications to be accepted.

3. REQUIRED EQUIPMENT

a. Suitable Laboratory Test Facility
b. Oscilloscope
c. Signal Generator
d. Spectrum Analyzer
e. Electronic Counter
f. Power Meters, (bolometers and calorimetric)
g. Frequency Meters
h. Jitter Tester
i. Directional Couplers
j. Attenuators and Calibrated Pads
k. Reference Marker Generator (Cyrstal-Controlled Oscillator

1. X-Y Recorder

4. REFERENCES

A. Terman, Fredrick E., Radio Engineering, McGraw-Hill Book Company, Inc., New York, 1947.
B. Massachusetts Institute of Technology, Radiation Laboratory Series, Selected Volumes, McGraw-Hill Book Company, Inc., New York, 1953.
C. Bell Telephone Laboratories, Radar Systems and Components, D. Van Nostrand Company, New York, 1949.
D. Van Nostrand, D., International Dictionary of Physics and Electronics, D. Van Nostrand Company, New York, 1961.

5. SCOPE

5.1 SUMMARY

This MTP describes in general terms the tests required to determine and evaluate such transmitter characteristics as accuracy and reliability. The test includes the procedures for conducting such tests within the confines of a laboratory suitable for such purposes.

The specific tests contained herein are summarized below:

a. Frequency Generator (Exciter) Tests - Transmitter frequency generators are subjected to the following tests:

1) Tuning range
2) Frequency stability
3) Frequency spectrum
4) Power output (average or peak)
5) Modulation capability (if required)
6) Operation under extreme ambient conditions required by specifications

b. Power Amplifier Tests - The power amplifier is tested for the following:

1) Gain bandwidth characteristics
2) Variation of power output
3) Frequency response range
4) Frequency and power output spectrum
5) Distortion due to amplifier
6) Modulation signal frequency, type, amplitude, and power

c. Modulator Tests - Modulators shall be subjected to the following tests:

1) Output waveshape and amplitude
2) Input waveshape required

3) Ability of modulator to deliver consecutive pulses (recovery time).
4) Pulse transformer output voltage waveshape

d. Synchronizer Tests - Synchronizers are subjected to the following tests:

1) Pulse waveshape (rise time, duration, and decay time)
2) Frequency stability of pulse repetition rate

5.2 LIMITATIONS

The procedures in this MTP are not intended to be peculiar to testing specific transmitters. They intentionally were made general to provide coverage for various types of systems. Special procedures are detailed in the applicable specifications, manufacturer's instructions, or Missile Purchase Descriptions (MPD's).

In addition to the laboratory tests conducted in accordance with the procedures contained in this MTP, field equipment is expected to operate properly under extremes of temperature, humidity, rain, snow, blowing sand, solar radiation and heat, with combinations of these conditions. Shock and vibration as well as extreme environments will be encountered during shipping, storage, and operation of the equipment. Therefore, additional testing should be performed to ensure that the equipment will operate under these adverse field conditions.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Select a suitable test facility (laboratory) especially equipped for the purpose of conducting engineering tests on transmitters under ambient conditions.

b. Select test equipment having an accuracy of at least 10 times that of the function to be measured.

c. Record the following information:

1) Nomenclature, serial number(s), and manufacturer's name of the test item(s)
2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests

d. Assure that all test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).

e. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous transmitter tests conducted on the same type of equipment, and familiarize

all test personnel with the contents of such documents. These documents shall be kept readily available for reference.

f. Thoroughly inspect the test items for obvious physical and electrical defects such as cracked or broken parts, loose connections, bare or broken wires, loose assemblies, bent relay and switch springs, corroded plugs and jacks, and bare or cracked insulation. All defects shall be noted on an applicable data form, and corrected before proceeding with the tests.

g. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation.

h. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety precautions are observed throughout the test.

6.2 TEST CONDUCT

6.2.1 Frequency Generator (Exciter Tests)

6.2.1.1 Frequency Range of Tuning

NOTE: For purposes of illustration, the procedure given is for measuring a frequency of 108.0 MC. However, any other frequencies may be measured using the same techniques.

a. Set up the frequency generator, a reference marker generator, a coaxial "TEE", and a spectrum analyzer as shown in Figure 1.

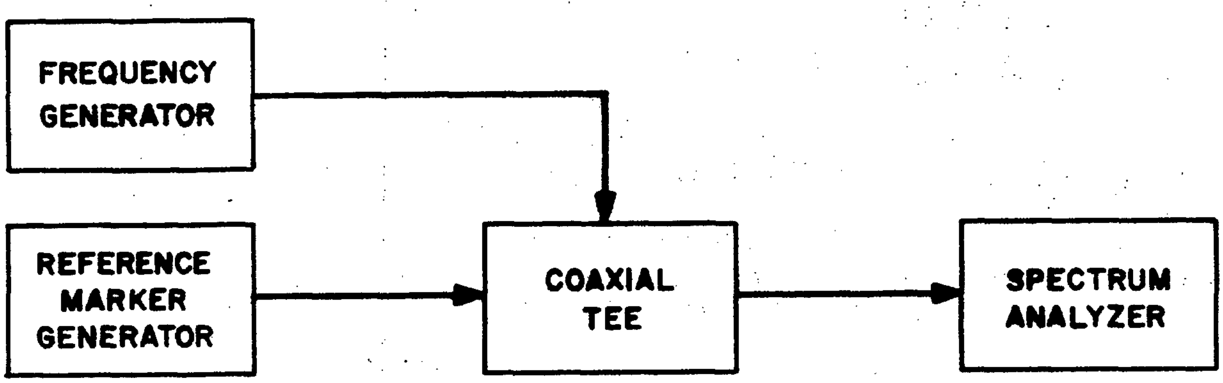


Figure 1. Spectrum Analyzer and high accuracy Marker Generator setup for measuring exciter frequency.

b. Tune the spectrum analyzer to 100 MC and set the WIDTH control to 10 MC/CM. (The centimeter marks on the graticule now represent 10 MC intervals from 50 to 150 MC).

c. Set the marker generator to the 100 MC repetition rate and note that a single 100 MC reference mark appears in the center of the analyzer display.

d. Momentarily key the frequency generator and note its approximate frequency from its position on the display. If the frequency generator is reasonably close to 108 MC, move the center marker representing 100 MC to the 1 - cm graticule line on the left side of the display by fine tuning the analyzer frequency.

e. Set the analyzer's WIDTH control to 1 MC/CM and stabilize the analyzer's local oscillator. (The analyzer is now sweeping from 99 to 109 MC).

f. Switch the marker generator to the 1 - MC repetition rate and note that a marker is produced at each centimeter of the display graticule.

g. Key the frequency generator and note that its output response appears eight centimeters above the 100 MC marker on the analyzer display.

h. Perform steps (b) through (g) above, at each end of the frequency extremes and at the center frequency of the frequency generator under test, and record amount of frequency error for each position on a suitable data form.

6.2.1.2 Frequency Stability under Rated Temperature and Load

a. With the equipment in the same configuration established in Paragraph 6.2.1.1 above, stabilize the frequency generator in the center of its rated temperature range and terminate it with its rated load.

b. Measure the frequency generator frequency at each end of its frequency extremes and at the center frequency as outlined in Paragraph 6.2.1.1 above, every two hours for at least twenty-four hours.

c. Record the amount of frequency drift at each 2-hour interval of the 24 - hour cycle, on a suitable data form.

6.2.1.3 Frequency Spectrum

a. With the equipment in the same configuration established in Paragraph 6.2.1.1 above, slowly tune the frequency generator throughout its range while observing the analyzer display for spurious signals.

NOTE: A spurious response is easily determined. Simply note the amplitude of a signal on the logarithmic display of the analyzer and switch in 10 db more input attenuation. If the amplitude of the response decreases by 10 db (1 - CM on the log display) the signal is genuine. If the amplitude decreases by more than 10 db, the response is spurious.

b. Record frequency and amplitude of any spurious response encountered on a suitable data form.

6.2.1.4 Average and peak Power Output

a. Connect a reflectometer, a slide screw tuner, a thermistor mount (bolometer), and a power meter as shown in Figure 2.

b. Using the reflectometer, adjust the tuner for minimum reflection.

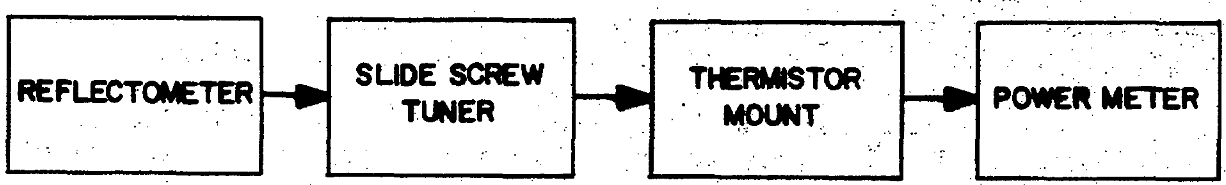


Figure 2. Test configuration for measuring average power. Tuner eliminates mismatch between exciter and thermistor mount, removing reflection coefficient terms from measurements.

c. Without distrubing the tuner setting, remove the reflectometer and connect the exciter to the thermistor mount and tuner combination.

d. With the exciter power turned off, null and zero the power meter according to the operating manual.

e. Switch the power meter to the appropriate range for the maximum power expected, and energize the transmitter exciter.

f. Read the average power from the meter and record on a suitable data form.

g. Remove the power meter, thermistor mount, and tuner from the exciter and connect the exciter to a crystal detector with a square-law load and oscilloscope as shown in Figure 3.

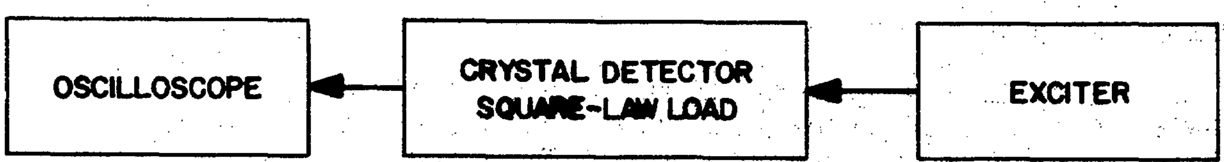


Figure 3. Test configuration for measuring peak power. (A square law detector has an output signal strength proportional to the square of the RF input voltage).

h. Measure and note the pulse repetition frequency (PRF) and pulse width (τ) using the oscilloscope's calibrated sweep.

6.2.2 Power Amplifier Tests

6.2.2.1 Gain Bandwidth Characteristics

a. Setup a sweep oscillator, two power meters, two directional couplers, a sliding load, and an X-Y recorder as shown in Figure 4.

b. With no power applied to the circuit, null and zero the power meters in accordance with applicable instructions.

c. Energize the sweep oscillator and calibrate the circuit for a

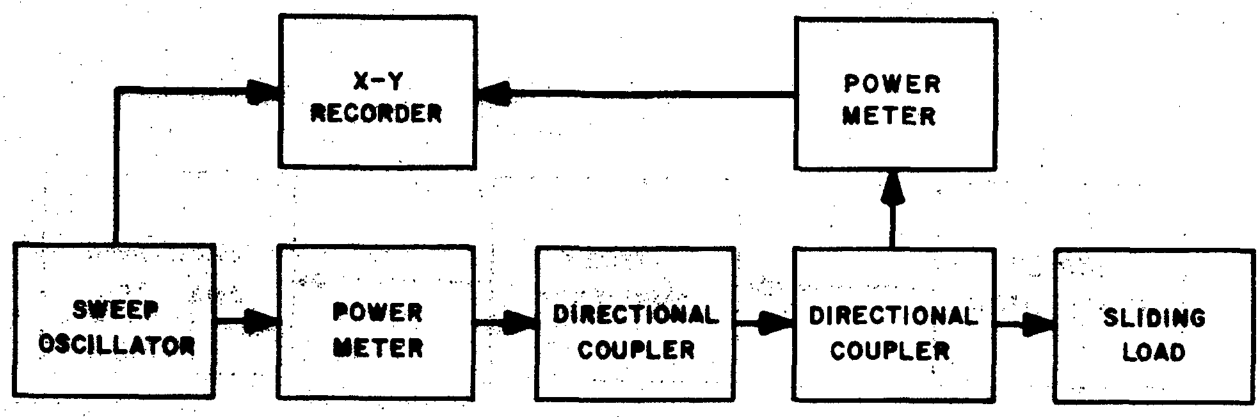


Figure 4. Frequency response and gain test on power amplifier. Use power meter leveling and readout to monitor actual power levels.

leveled power output with the oscillator slowly sweeping the full frequency range of the amplifier under test.

d. Setup the X-Y recorder for on-scale operation and negative vertical input, and plot a gain reference trace using manual operation.

e. Plot a second trace 3 db above the gain reference trace plotted in step (d) above.

f. Insert the test amplifier into the circuit between the directional couplers and plot a gain versus frequency trace for the amplifier (see Figure 5).

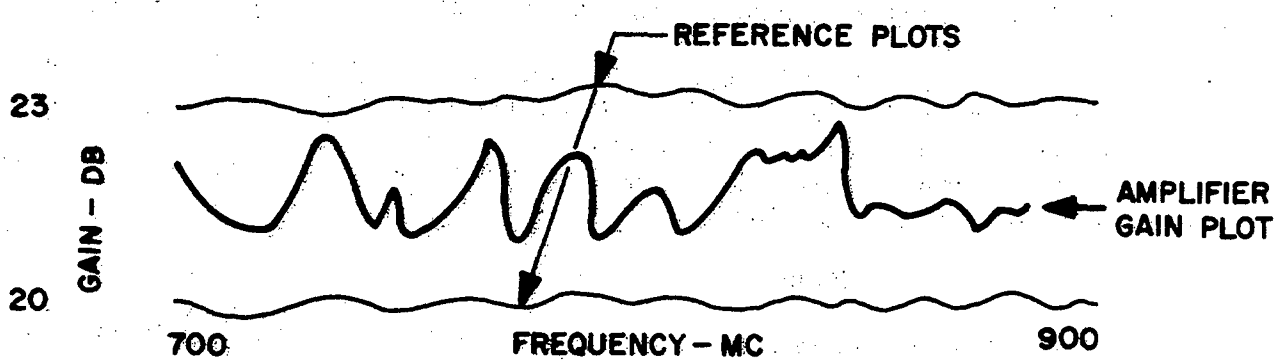


Figure 5. X-Y plot of amplifier gain test.

g. Connect a sweep oscillator, the test amplifier, and a spectrum analyzer as shown in Figure 6.

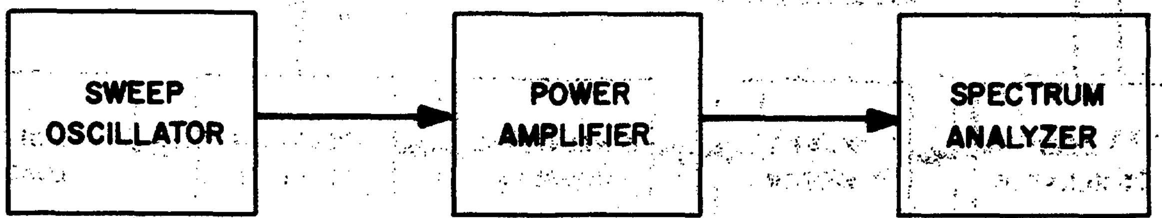


Figure 6. Spectrum analyzer and high accuracy signal generator setup for measuring bandwidth.

h. Set the sweep oscillator at the center of the amplifier frequency range and adjust power output as desired.

i. Tune the spectrum analyzer for maximum signal response on the CRT with the spectrum width at 1 MC/CM and sync at interval. Stabilize analyzer local oscillator per operating and service manual.

j. Select log display on analyzer so vertical scale is now calibrated in db. Adjust IF gain and input attenuation for full scale indication of test signal.

k. Reduce spectrum width to zero keeping the response centered on the display with fine tuning. The analyzer is now operating at only the test signal frequency. Adjust IF gain until response is just 7 - CM high.

l. Slowly adjust the output frequency of the signal generator clockwise until the signal response is reduced 3 - CM. Record this frequency on a suitable data form.

m. Slowly adjust the output frequency of the signal generator counterclockwise until the signal response is again reduced 3 - CM. Record this frequency on a suitable data form.

n. Repeat steps (i) through (m) above, at each extreme end of the power amplifier frequency range.

6.2.2.2 Power Output Range

a. For measurements of less than 10 milliwatts, connect the equipment as shown in Figure 7.

1) Select the proper thermistor operation resistance, and energize the meter.
2) Null and zero the power meter.

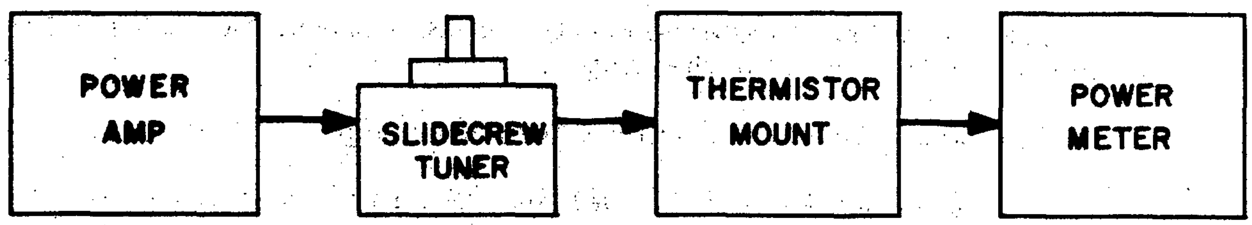


Figure 7. Setup of Equipment for measurements of less than 10 milliwatts.

3) Select the appropriate power range for the maximum power expected.
4) Connect the power amplifier, a slide screw tuner, a thermistor, and a power meter in series as shown in Figure 7.
5) Adjust the tuner for a maximum power indication on the meter for conjugate available power. For Zo available power adjust the tuner - mount combination for minimum reflection on a Q meter or slotted line before connecting to the source in test. Record the power levels.
6) For frequencies greater than 2.6 GHz and up to 40 GHz a directional coupler may be inserted between the slide screw tuner and the thermistor mount as shown in Figure 8.

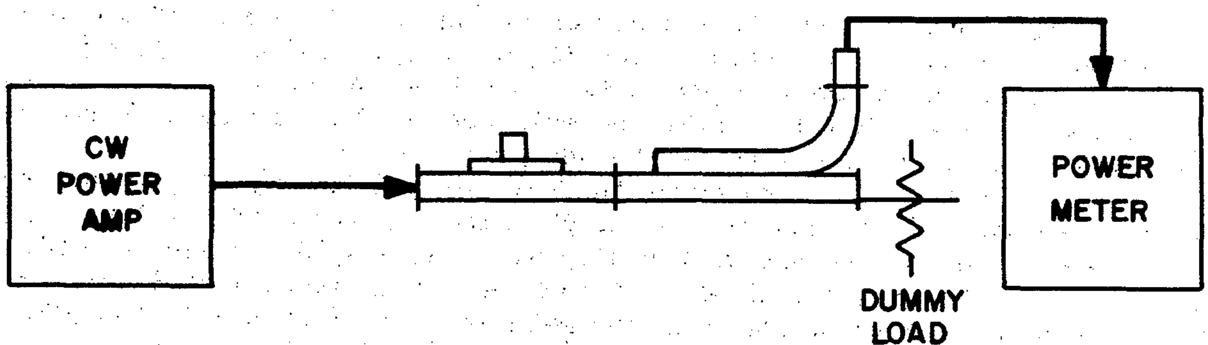


Figure 8. Measurement of Power using a directional coupler.

7) The power range with this system may also be extended to 1 watt.

b. For measurements between 10 MW and 10 KW.

The techniques are essentially the same except that a calorimeter power meter is used instead of a thermistor.

1) Make the initial calorimeter adjustments.

(a) Check the oil level and flow rate and zero the meter according to the service manual.
(b) Set the range switch to 0.1 watt.
(c) Connect the meter calibrate output jack to the input jack of the meter and adjust the meter for full-scale reading of 0.1 watt.
(d) Disconnect the calibrate output from the input and recheck meter zero.

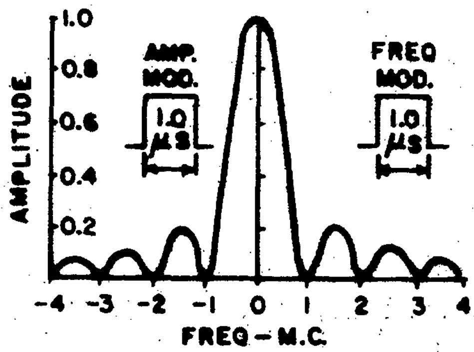
2) Set the range switch for the maximum power expected from the source to be measured.
3) Connect the source to the meter and read average power.
4) For higher frequencies slide screw tuners and directional couplers may be used to match the source to the meter.

6.2.2.3 Tuning Range

a. With the exciter connected to the power amplifier turn on the transmitter and tune the exciter to its highest operating frequency.
b. Connect a VTVM to the output of the power amplifier and adjust the amplifier for maximum response.
c. Record the frequency and output readings.
d. Repeat the test for the lowest operating frequency.

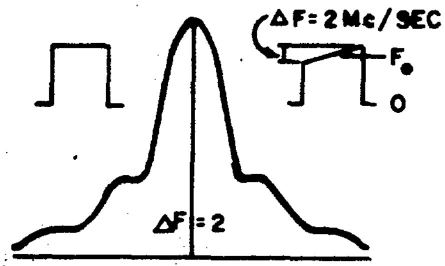
6.2.2.4 Frequency and Power Spectrum of Output and Distortion of Input Signal

a. Connect a spectrum analyzer RF input to a sample of the transmitter power through a directional coupler of at least 30 db coupling.
b. With the radar high voltage on, tune the analyzer to the transmitter frequency which will center the main lobe of the transmitter frequency which will center the spectrum of the analyzer screen.
c. Check over loading of the analyzer's mixer by increasing the RF input attenuator of the analyzer by 10 db. The amplitude of the lobes should decrease by 10 db on the analyzer's display. The display should be symmetrical approximating the envelope shown in Figure 9. If incidental FM is present, it will show up as a loss of power in the main lobe and increase in the side lobes as shown in Figure 9 and 10. The addition of linear AM causes the spectrum to become unsymmetrical as shown in Figures 9 and 10. Incidental AM alone causes the side lobe amplitudes to decrease while the main lobe remains symmetrical as illustrated in Figure 9.



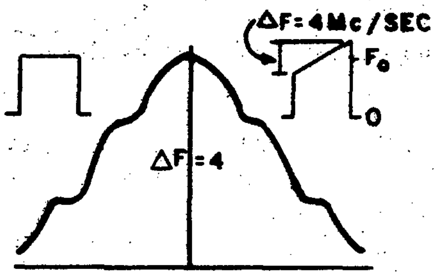
(A)

Spectrum of rectangular pulse without AM or FM occurring during pulse. Shape is that a $\frac{\sin \omega\tau/2}{\omega\tau/2}$ function.



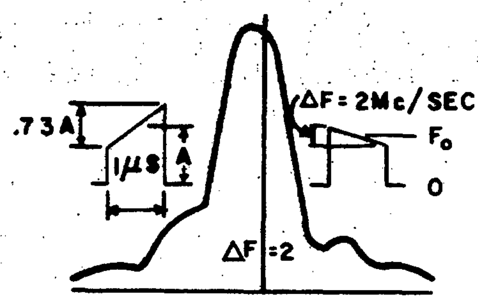
(B)

Spectrum of rectangular pulse with linear FM resulting in increased sidelobe amplitude and minimas not reaching zero.



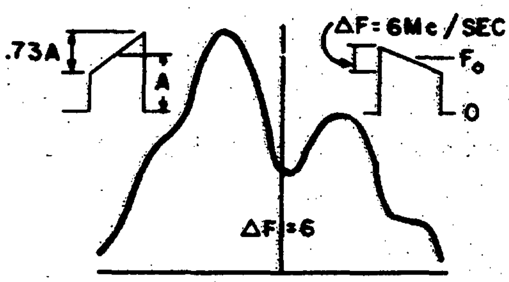
(C)

Same pulse spectrum as (b) with more severe FM



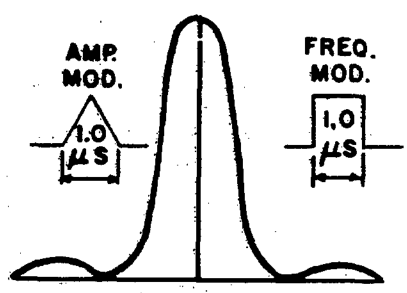
(D)

Effect of linear AM and FM during pulse. Note loss of symmetry due to pulse amplitude slope.



(E)

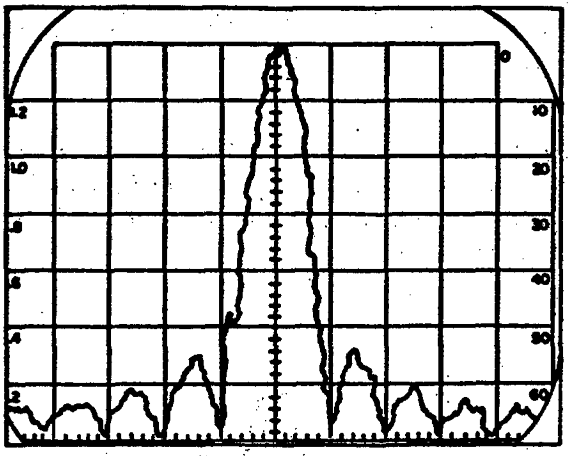
More severe case of FM and AM ccurring during pulse.



(F)

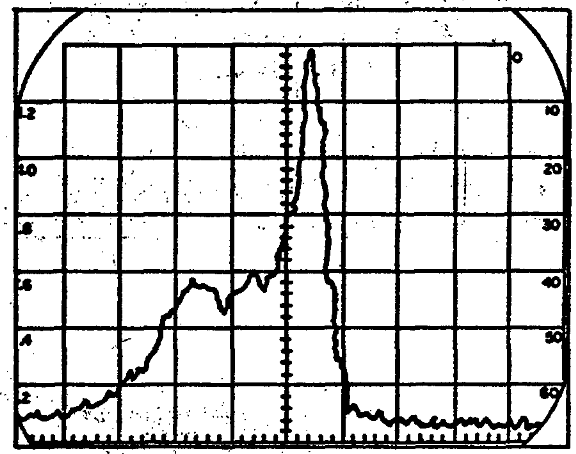
Triangular pulse spectrum without FM during pulse. Effective pulse width is shorter than (a) causing minimas to occur at wider intervals of frequency.

Figure 9. Common Pulse Spectra



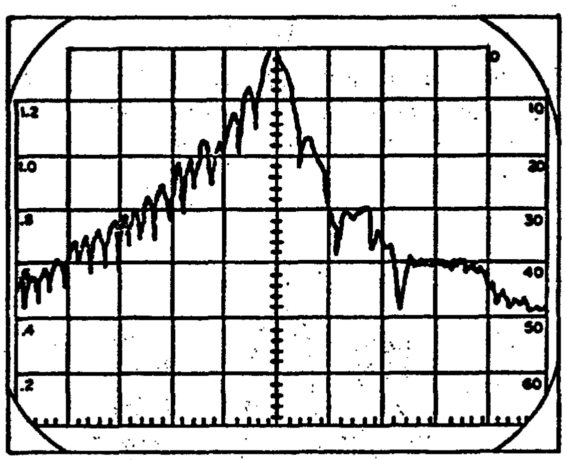
(g)

Good $\frac{\sin \omega\tau/2}{\omega\tau/2}$ spectrum of a 1 - µ s e c RF pulse. Analyzer set for linear vertical display and 1 MC/CM spectrum width.



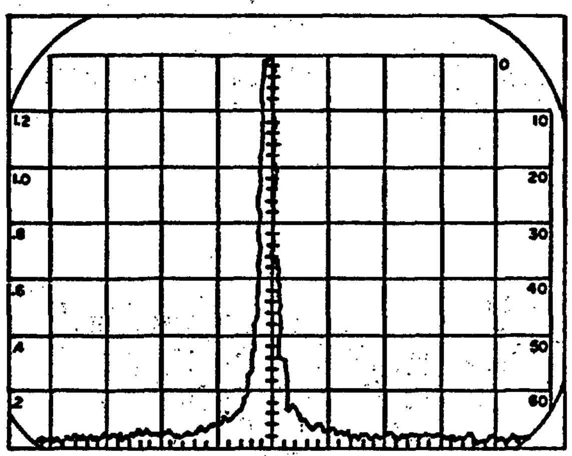
(h)

Reflector modulation of a klystron with 1 -kc square wave. Linear display, 1 MC/CM. Note lack of symmetry due to incidental FM along with AM



(i)

Spectrum of a 4.5 - µsec RF pulse at 300 pps showing AM and FM effect caused from a poorly operating magnetron. Vertical Display set to Log.



(j)

Same as spectrum (i) showing loss in sidelobe detail because of analyzer Vertical Display set for Linear.

Figure 10. Common Pulse Spectra (Cont'd)

d. For closer observation of the side lobes, switch the analyzer to a logarithmic display so the main lobe will be compressed and the side lobes enlarged by the response of the analyzer. The photo in Figure 10 is an example of good and bad spectrum commonly encountered in the field. Figure 9 points out the advantage of the accurate log display used in Figure 9 for good side lobe detail.

6.2.2.5 Pulse Characteristics

a. With the equipment connected as in the previous test measure the frequency spread of the main lobe using the calibrated Spectrum Width Control and CRT graticule. Take the measurement at the minimum of the main lobe.
b. Take the measurement of the width of the side lobes.

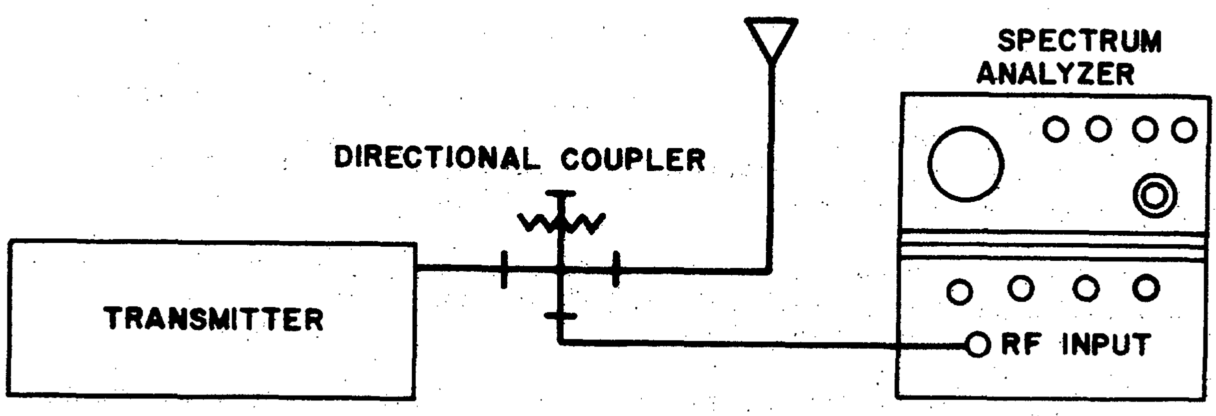


Figure 11. Spectrum Analyzer connected for checking Transmitter Operation

6.2.3 <u>Modulator Tests</u>

6.2.3.1 Pulse Repetition Frequency Measurements

a. Connect a crystal detector to the output of the transmitter by means of a directional coupler.
b. Connect the vertical input probe of a High Frequency Oscilloscope to the output of the detector.
c. Turn on the equipment and adjust the transmitter for its various modulating frequencies.
d. Record the PRF from the trace of the oscilloscope.

6.2.3.2 Frequency Stability

a. With the equipment connected as in Figure 11, use the main tuning dial on the analyzer to place the center of the main lobe at some

convenient reference mark along the X axis of the CRT.

b. Watch for continuous movement of the entire spectrum across the screen which will indicate frequency drift of the magnetron.

c. Note the total shift of the spectrum in centimeters on the X axis and multiplying by the SPECTRUM WIDTH setting of the analyzer.

d. To check for pulling effect on a magnetron connect the equipment as before, and with the antenna rotating observe the spectrum shift as in the frequency drift test.

e. A periodic shift left and right or a breathing effect of the entire spectrum indicates that "pulling" is taking place.

6.2.3.3 FM Deviation Movement

The accuracy of frequency modulation or the residual frequency modulation of a transmitter can be measured by the following method.

a. Connect the transmitter under test to the input of the spectrum analyzer.

b. Adjust the analyzer and the transmitter so that the carrier frequency is centered in the display.

c. Connect an audio oscillator to the input terminals of the FM modulator. Also connect an electronic counter to the output of the audio oscillator.

d. Set the frequency of the audio oscillator by means of the counter to the modulating frequency that will produce maximum deviation.

e. Increase the amplitude of the modulating signal until the carrier amplitude on the display goes to zero.

f. When this condition exists all of the energy of the transmitted signal is concentrated in the side bands, and the width of the spectrum is the deviation of the carrier from center frequency. Record the width of the spectrum.

g. The residual FM of a transmitter may be checked by observing any periodic movements of the analyzer display.

6.2.3.4 AM Signal Measurements

a. Connect a audio oscillator to the input of the amplitude modulator.

b. Connect a oscilloscope to the output of the transmitter.

c. Adjust the audio oscillator output until 100% modulation is observed on the oscilloscope.

d. Vary the frequency of the audio oscillator until distortion is observed on the CRO.

e. The input wave shapes and the recovery time of the modulator may be observed in a similar manner.

6.2.4 <u>Synchronizer Tests</u>

a. Connect a signal generator to the input of the synchronizer, and a spectrum analyzer to the output.

b. With the signal generator set to the center frequency of the synchronizer observe the spectrum analyzer, for indications of proper waveshape

and spurious responses. Parameters to observe are: rise time, decay time, and jitter.

6.3 TEST DATA

6.3.1 Frequency Generator Tests

6.3.1.1 Frequency Range of Tuning

a. Record frequency error in Hz

6.3.1.2 Frequency Stability under Rated Temperature and Load

a. Record Rated Temperature in degrees Kelvin.
b. Record Rated Load in Watts.
c. Record Time in hours.
d. Record Frequency Drift in Hz.

6.3.1.3 Frequency Spectrum

a. Record Frequency in Hz.
b. Record Amplitude in Volts.

6.3.1.4 Average and Peak Power Output

a. Record Average Power in Watts.
b. Record PRF in Hz.
c. Record τ in μ sec.

6.3.2.0 Power Amplifier Tests

6.3.2.1 Gain Bandwidth Characteristics

a. Record the Frequency in Hz at the $\frac{1}{2}$ power points.
b. Record the Center Frequency in Hz.

6.3.2.2 Power Output Range

a. Record Power Output in Watts.

6.3.2.3 Tuning Range

a. Record Output in Watts
b. Record Frequency in Hz.

6.3.2.4 Frequency and Power Spectrum of Output and Distortion of Input Signal

a. Record the Shape of the Analyzer Display.
b. Record the Amplitude of the lobes in mV.
c. Record the Center Frequency in Hz and the pattern width in Hz.

6.3.2.5 Pulse Characteristics

a. Record the Frequency spread of the main lobe in MHz.
b. Record the Frequency spread of the side lobes

6.3.3.1 Modulator Tests

a. Pulse Repetition Frequency Measurements.
b. Record Frequency in Hz.

6.3.3.2 Frequency Stability

a. Record Frequency drift in Hz.

6.3.3.3 FM Deviation Measurement

a. Record Deviation in Hz.

6.3.3.4 AM Signal Measurements

a. Record the Modulating Frequency in Hz.
b. Record the waveshape of the Modulated Signal.

6.3.4 Synchronizer Tests

a. Record rise time, decay time, and jitter in microseconds.
b. Record amplitude in mV of spurious responses and frequency in Hz at which they occur.
c. Record the center frequency of the synchronizer.

6.4 DATA REDUCTION AND PRESENTATION

Compare the data taken during the test to the criteria set forth for the transmitter under test. All power readings should be reduced to db's by use of the formulas $db = 10 \log \frac{Po}{Pi}$.

The frequency can be determined from an Oscilloscope display by use of the formula:

$$f = \frac{10^6}{T}$$

where: f = frequency in cycles per second

T = times difference between two successive pulses in microseconds

The criteria for determining rise time and pulse width for the RF pulse envelope of a pulse transmitter are rise time, the time required for the tube to rise from 10% to 90% of its final value, and the pulse width, defined as the time between the 50% points of the pulse amplitude.

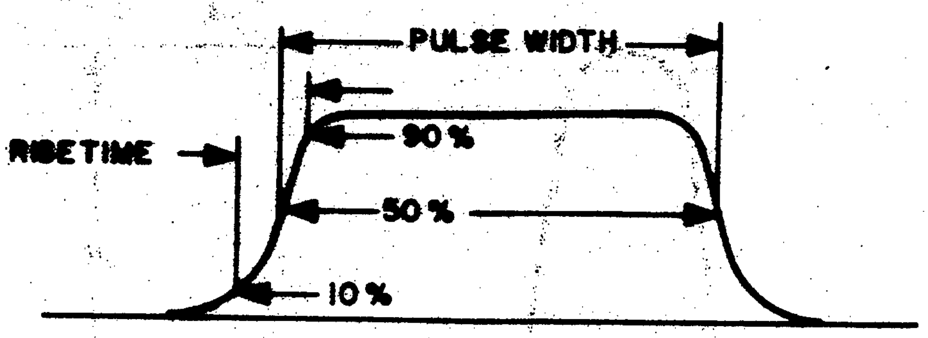


Figure 12. Oscilloscope Presentation of Pulse Envelope

The main lobe should be 20 times the amplitude of the first side lobe for the spectrum an ideal pulse. The relationship between width of the pulse and the spectrum minimum of the ideal pulse is shown in Figure 13.

The peak pulse power should be calculated using the following equation:

$$P_{pk} = (PRF x \tau) \quad \log_{10}^{-1} \frac{DB}{10}$$

where P_{pk} = Peak power of transmitter exciter

PRF = Pulse repetition

τ = Pulse width

DB = Coupling factor of slide screw tuner

The amplifier bandwidth (Δf) in Section 6.2.2.1 is calculated as the difference between the frequency reading obtained in step (l) and (m). Calculate the circuit selectivity (Q) as, $Q = fo/\Delta f$.

where: fo = frequency of maximum signal response

Δf = frequency difference between the half-power points

Some typical values of Pulse width for given distance between the first minimum MHz (D) are:

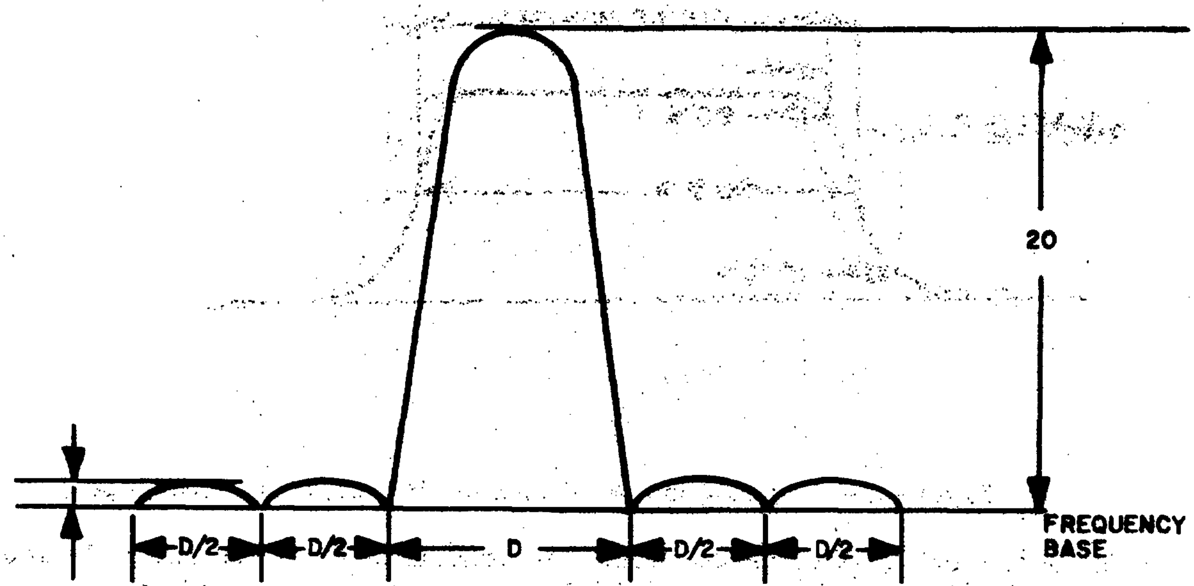


Figure 13. Power Spectrum of an Ideal Pulse.

Pulse Width	D
1/4 μ sec.	8 MHz
1/2 μ sec.	4 MHz
1 μ sec.	2 MHz
2 μ sec.	1 MHz
4 μ sec.	1/2 MHz

The modulating pulse width τ in micro seconds may be calculated by the equation $\tau(\mu\text{sec}) = \frac{2}{f\,(\text{MHz})}$ where f (MHz) = measured main lobe width in mega cycles. Pulse width may be calculated from measurements of any of the side lobes also, depending on the preference of the operator. Simply divide the right-hand member of the equation by 2, since the side lobes are exactly half the main lobe width.

GLOSSARY

1. Bolometer: A bolometer is a temperature sensitive resistance element. In microwave technology, a barreter, thermister or other device utilizing the temperature coefficient of resistivity of some resistance element is called a bolometer. A barreter is a fine platinum wire with a positive temperature coefficient. A thermister is a small bead of semiconducting material with a negative temperature coefficient.

2. Bolometer Mount Efficiency: The portion of the RF power delivered to the mount which is absorbed by the bolometer element itself divided by the total amount of power delivered to the mount is the mount efficiency.

3. Frequency Drift: The change in frequency of an oscillator as a function of time. The change may be due to changes in temperature, supply voltages, voltages, humidity, or physical dimensions caused by wear. This generally is a slow change of frequency rather than an extremely fast shift of frequency.

4. Jitter: Short time instability of a signal. The instability may be in either amplitude or phase, or both.

5. Jitter, Tracking: Minor variations in the pointing of an automatic tracking radar antenna.

6. Jitter Scope: An oscilloscope used to measure jitter.

7. Pulse Width Jitter: Random variation of the width of the received or transmitter pulse.

8. Reference Jitter: Jitter of one pulse with respect to a reference pulse.

9. Pulling: Magnetron pulling is a frequency shift of a magnetron caused by factors which vary the standing-wave ratio or the disposition of standing waves on the RF lines.

10. Pulling Figure: The difference between the maximum and minimum values of the oscillator frequency when the phase angle of the load-impedance phase reflection coefficient varies through 360 degrees while the absolute value of this coefficient is constant and equal to 0.20 (VSWR = 1.51).

11. Pulse Modulation: Modulation of a carrier by a pulse or modulation of a pulse carrier. The term is used to describe the process of generating carrier frequency pulses or a method of transmitting information on a pulse carrier.

12. Pulse-Amplitude Modulation (PAM): Modulation in which the modulating wave is caused to amplitude modulate a carrier. Two types of amplitude modulation may be employed. Bidirectional PAM employs pulses for positive and negative polarity with the average value equal to zero. Undirectional PAM employs pulses of one polarity.

13. Pulse-Code Modulation (PCM): Modulation which involves a code. Generally, it is that form of pulse modulation in which a code is used to represent quantized values of instantaneous values of samples of the signal wave. The term PCM is also used for pulse count modulation.

14. Pulsed Doppler System: A pulsed radar system which utilizes the doppler effect for obtaining information about the target, especially velocity.

15. Pulse-Duration Modulation (PDM, PWM, or PLM): Pulse-time modulation in which the value of each instantaneous sample of the modulating wave is caused to modulate the duration, width, or length of a pulse. The terms pulse width, pulse length, or pulse duration all apply to the same type of modulation.

16. Pulse-Frequency Modulation (PFM): A form of pulse-time modulation in which the pulse repetition frequency of the carrier is varied in accordance with the amplitude and frequency of the modulating signal. A more precise term would be pulse repetition rate modulation.

17. Pulse-Interval Modulation (PIM): A form of pulse-time modulation in which the pulse spacing is varied.

18. Pulse-Position Modulation (PPM): Pulse time modulation in which the value of each instantaneous sample of a modulating wave is caused to modulate the position in time of a pulse.

19. Pulse-Time Modulation (PTM): Modulation in which the values of instantaneous samples of the modulating wave are caused to modulate the time of occurrence of some characteristic of a pulse.

20. Pushing: Magnetron pushing is the frequency shift of a magnetron caused by faulty operation of the modulator. Any change in an operating parameter may cause pushing. Conditions which may cause pushing are: An improperly shaped pulse, interaction of pulse with the magnetic field, or improper modulator loading by the magnetron. Pushing usually is indicated by a poor spectral display.

21. Pushing Figure: The difference between the values of oscillator frequency measured at specific values of direct electrode current (frequency changes caused by thermal effects are excluded). A measure of the dependence of oscillator frequency upon electrode currents.

22. Squegging: Squegging is the condition of self-blocking in an oscillator. It is the interruption of an oscillation at an RF or AF rate. Hence, the spectrum of a squegging oscillator will resemble that of a pulse modulated signal containing side band components as well as the oscillating frequency.